

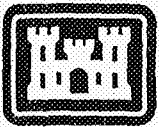
**Flood Damage Reduction**

**Reconnaissance Report**

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# **Silver Beach/Cedar Beach Milford, Connecticut**

**October 1991**



**US Army Corps  
of Engineers**  
New England Division

**RECONNAISSANCE REPORT  
SECTION 205**

**SILVER & CEDAR BEACH  
MILFORD, CONNECTICUT**

**OCTOBER 1991**

**RECONNAISSANCE REPORT  
SECTION 205  
SILVER & CEDAR BEACH  
MILFORD, CONNECTICUT**

## **INTRODUCTION**

This Reconnaissance Report presents the results of investigations of the feasibility of providing local flood protection along the Silver Beach and Cedar Beach areas of Milford, Connecticut. This investigation was initiated after the city of Milford's Flood and Erosion Control Board requested the Corps conduct a Reconnaissance Study of the Silver and Cedar Beach areas to determine if there are homes which would qualify for participation in a flood protection project.

This reconnaissance study phase is the first of a two-phase planning process and provides the basis for determining whether to continue into the feasibility or second phase. The feasibility phase includes a detailed investigation of alternative solutions, selection of a plan and results in a report which recommends a project for construction.

## **STUDY AUTHORITY**

This report was prepared under the special continuing authority of Section 205 of the 1948 Flood Control Act, as amended. This authority specifies that, each project constructed must be complete in itself. It must be economically feasible, which means the annualized benefits from the project must exceed the annualized costs of implementation. It must also be environmentally acceptable to local, State and Federal officials. Items of local cooperation, including cost sharing, shall be provided by a legally empowered and financially responsible local sponsor.

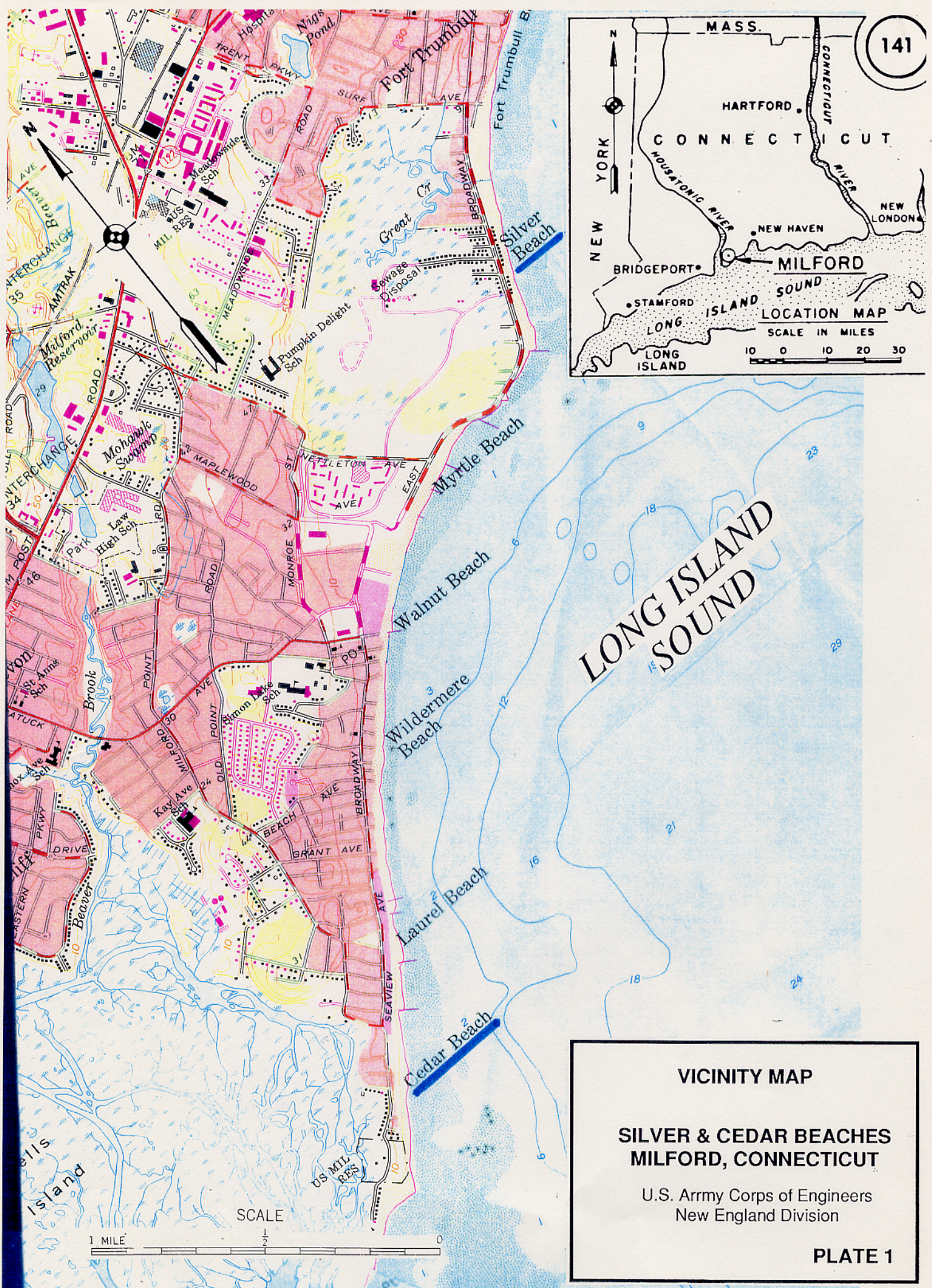
## **STUDY AREA**

This investigation specifically addresses flooding problems over 3/4 mile of shoreline along Silver Beach and Cedar Beach in Milford (see Plate 1, Vicinity Map). The limits of this study extend from Surf Avenue to Pearl Street in the Silver Beach area, and from Derby Avenue to Francis Street in the Cedar Beach area. The focus of the study is to provide protection for properties in the study areas which have a potential to sustain major damage as a result of a 1 percent chance (100 year) flood event. There are 190 homes located in the 100 year flood plain in the Silver Beach area and another 52 in the Cedar Beach area.

## **STUDY OBJECTIVE**

The West Central Connecticut Study, completed in 1988 by the Corps of Engineers, determined that local flood protection projects at either the Silver or Cedar beach areas were not economically justified. The primary objective of this reconnaissance investigation is to expand upon these earlier study findings and develop flood control plans that would reduce flood losses. Because the West Central Connecticut Study made many assumptions which affect the justification of a flood damage reduction project, further investigation was necessary to check the validity of the more critical assumptions.







## **ONGOING STUDIES & INVESTIGATIONS**

*Hurricane Evacuation Study* - In November of 1986, the Corps of Engineers, at the request of the Federal Emergency Management Agency (FEMA) and the State of Connecticut, Office of Civil Preparedness, initiated a hurricane evacuation study for the coastal communities of Connecticut. The study is part of an ongoing National program to identify portions of the coastal United States vulnerable to hurricane flooding. The Corps of Engineers participates in this program under the authority of the Flood Plain Management Services (FPMS) Program.

*Point Beach and Bayview Beach, Milford, CT*- A favorable Reconnaissance Report was completed, in November 1989, by the Corps of Engineers under Section 205 of the 1948 Flood Control Act, as amended. The report recommends a non-structural shore protection project involving the raising of 52 homes in the Point Beach area above the 100 year flood level.

*Woodmont Beach, Milford, CT* - In October 1989 a Detailed Project Report was completed, by the Corps of Engineers, under Section 103 of the 1962 River and Harbor Act, as amended. The report recommended a project to protect the back shore area of Woodmont Beach. The project involves the placement of sand fill along 1500 feet of beach and the reconstruction of two stone groins between Clinton Avenue and Bonsilene Avenue.

## **REPORT AND STUDY PROCESS**

The two phase planning process provides a mechanism to accommodate significant non-Federal participation in Corps feasibility studies, thereby, contributing to an efficient and effective planning process. The reconnaissance (first) phase provides a preliminary indication of the potential of the study to yield solutions, that are economically justified, which could be recommended as Federal projects. The results of the reconnaissance phase provides the basis for decision-making by the Corps and local interests to evaluate the merits of continuing the study and allocating feasibility (second) phase funds.

## **EXISTING CONDITIONS**

### **BACKGROUND INFORMATION**

Milford is located in south central Connecticut adjacent to Long Island Sound, approximately 75 miles northeast of New York City and 10 miles southwest of New Haven, Connecticut. The first pioneers of Milford were among the earliest settlers of the United States and developed the area industrially. Today Milford has evolved into a center of economic and industrial activity serving several surrounding cities and towns.

## **STUDY AREA DESCRIPTION**

Connecticut is a popular vacation and tourist area and is aptly termed the gateway to New England. The State is approximately 100 miles long in an east-west direction, and 50 miles wide in a north-south, direction. The entire southern boundary of the State is the north shore of Long Island Sound, a narrow, sheltered arm of the Atlantic Ocean. The fact that Connecticut is located in a temperate latitude and that the waters of Long Island Sound are generally calmer and warmer than along the exposed ocean shores of neighboring states has induced intensive development of the shoreline. The Connecticut shore is also very irregular, about 165 miles long, dotted with bays, coves, and near-lying islands, all of which add variety to the area and to its value for resort and residential development.

The study area is located along the north shore of Long Island Sound in the west-central portion of Connecticut. The Silver Beach area extends westerly from Surf Avenue to Pearl Street, about 1/2 mile. There are 190 houses within the 100 year flood plain at El. 10.4 NGVD in the Silver Beach area. The Cedar Beach area extends from Derby Avenue to Francis Street, about 1/3 of a mile. The Cedar Beach area contains 52 structures within the 100 year flood plain at El. 10.2 NGVD ( see Plates 2 & 3 Study Area Plans).

## **CLIMATOLOGY**

Milford has a variable climate characterized by frequent but short periods of heavy precipitation. The study area is influenced by prevailing "westerlies" that travel across the country in an easterly and northeasterly direction, and of larger weather systems of tropical origin that travel up the eastern seaboard. The severe winters normally experienced in New England are moderated somewhat by the presence of Long Island Sound, leaving the area with less snowfall on average than the rest of the region. Temperatures average about 50 degrees Fahrenheit year round, with extremes ranging from lows in the minus 20's to highs in the low 100's. Precipitation averages about 44 inches annually distributed uniformly throughout the year.

## **SOCIO-ECONOMIC SETTING**

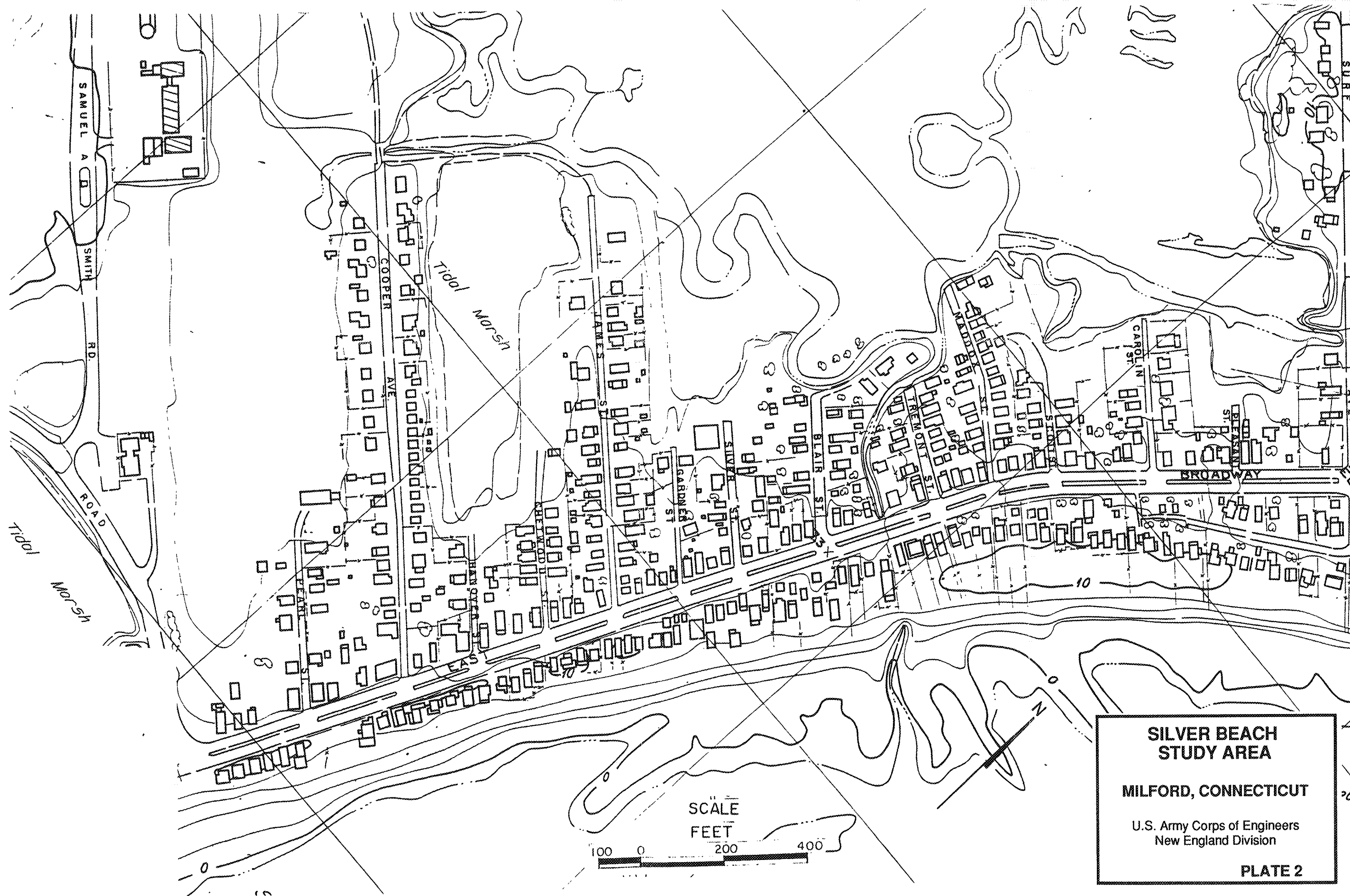
*Land Use* - Milford has an area approximately 24 square miles. Almost 60 percent of the land is developed in residential uses, and 10 percent is devoted to commercial and industrial development. The study areas of Silver and Cedar Beach are exclusively residential.

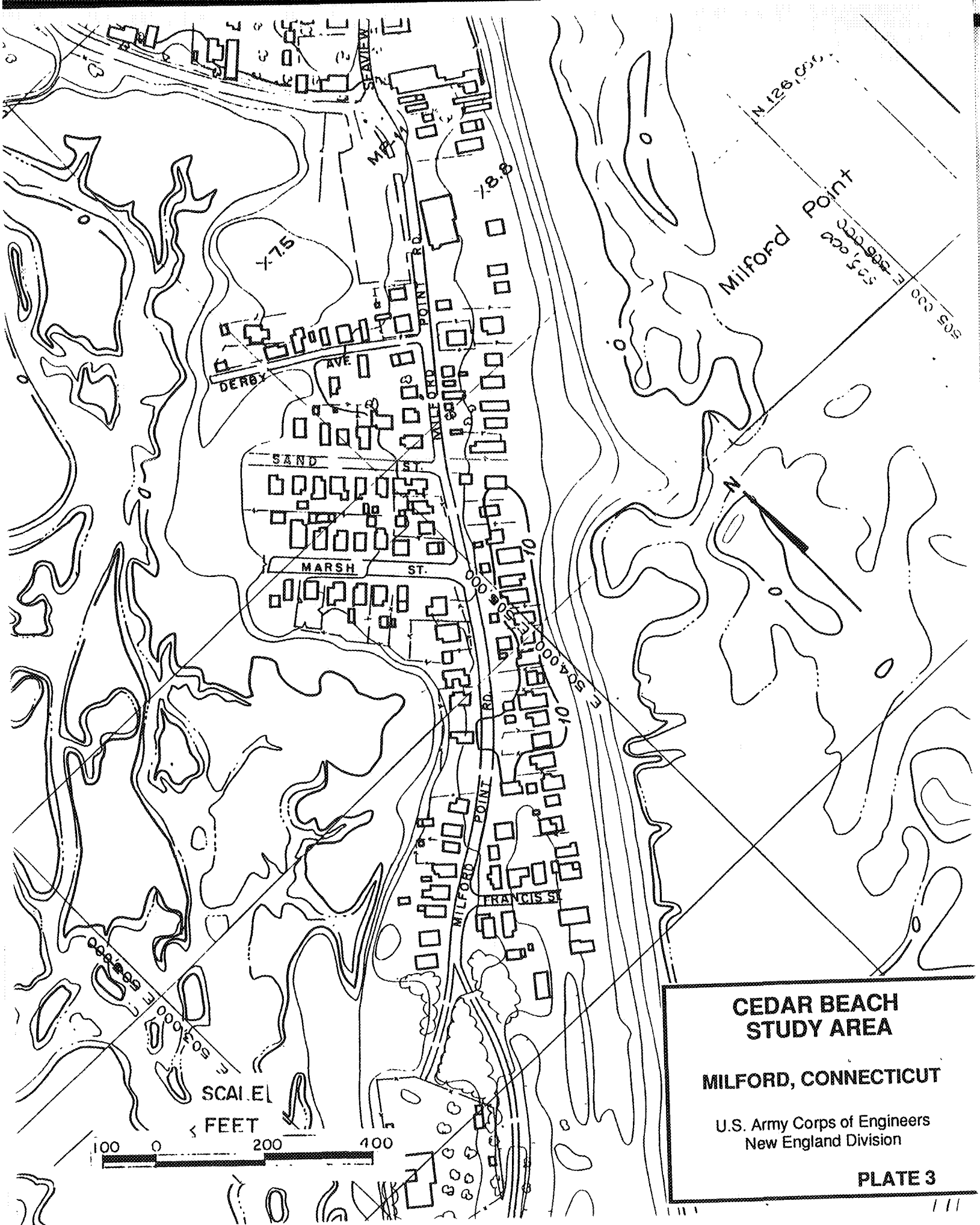
*Economy and Population* - Over the last 50 years, Milford saw its greatest period of growth between 1940 and 1950 when its population increased 63.5 percent. Census figures for 1990 show a population of 50,898 for Milford. Milford's population increased 1.5 percent between 1980 and 1990. The statewide population change between 1980 and 1990 was 5.8 percent. Current projections predict the population of Milford to increase by about 5.2 percent by the year 2000.

## **TIDAL FLOOD HISTORY**

Tidal flooding within the study area is caused primarily by hurricanes or tropical storms. Hurricanes have been the most damaging, because their intensity has had a greater affect on tide levels and wave heights.







**CEDAR BEACH  
STUDY AREA**

**MILFORD, CONNECTICUT**

U.S. Army Corps of Engineers  
New England Division

**PLATE 3**



Hurricanes can be defined as tropical cyclones with a maximum wind speed in excess of 75 miles per hour. Their diameter can vary considerably, from as small as 50-75 miles across to over 500 miles wide. Winds at the outer edge are usually light and increase in intensity as they approach the center. Hurricanes that have had the most severe affect on the study area usually approach from the south after curving east of Florida and skirting the coastline of the Middle Atlantic States.

Tidal floods produced by hurricanes and tropical storms have been responsible for badly damaging or completely destroying residential, commercial, and industrial structures, roadways and recreational beaches and park areas in developed coastal areas. From a social standpoint this destruction has caused a number of problems which include: the relocation of entire families and in some instances, neighborhoods; unemployment due to the destruction or severe damage to industrial and commercial establishments; the loss of recreational facilities such as beaches and parks as well as boats and marina facilities; the disruption to the flow of traffic due to road damage; and public health problems due to water supply contamination or destruction of sewerage disposal systems.

The two most damaging hurricanes experienced along Long Island Sound occurred during September 1938 and August 1954. Flood levels experienced during these events were used to prepare tidal flood profiles for areas along the shoreline. A detailed description of these hurricanes is given in the following paragraphs.

*Hurricane of September 21, 1938* - Tidal flooding from this hurricane was the greatest ever experienced in Long Island Sound. The center of the hurricane entered Connecticut about 15 miles east of New Haven and proceeded northwesterly at a forward speed of 50 to 60 miles per hour. The hurricane caused extreme high tides throughout most of the Sound, with a tidal surge of about seven feet (ft.) above the normal predicted tide at Bridgeport. Wave action accompanying the storm produced a devastating effect upon the shoreline, resulting in widespread damages. Wave heights ranged from ten feet at New London to 15 ft. at New Haven and Bridgeport.

*Hurricane of August 31, 1954 (Carol)* - The second most damaging hurricane to strike southern New England. The center of this storm crossed the shoreline of Connecticut near New London and then followed a general northerly path across New England. As the hurricane surge occurred at or near predicted normal high tide within the Sound, tide levels rose to near record heights. Tidal surges ranged from five to eight ft. higher than normal tides.

Damages from flooding of low shore areas occurred from hurricane Carol throughout Connecticut as a result of extremely high tides. Waves were particularly damaging east of the Connecticut River. Statewide damages occurred as a result of inundation of commercial and residential properties and coastal losses ranged from damage to fishing and pleasure craft, harbor facilities, shorefront residences and bathing beach establishments.

*Tidal Flood Problem* - Throughout history tidal floods produced by hurricanes and tropical storms have caused loss of life, massive damage to public and private property along Connecticut's shoreline. In addition to high water levels from tidal flooding, waves generated by wind, associated with severe storms, can, and have, caused serious damage to the coastline. Although wave measurements or statistical wave data is very limited in the study area, waves generated by southerly winds pose the greatest threat to the area. Since wave height is dependent upon wind speed and fetch distance, winds from southerly directions result in a much greater threat due to the relatively long fetch available in Long Island Sound.

In addition to the threat posed by coastal storms, the New England coastline is experiencing a phenomenon known as sea level rise. In the study area, this rise has been about one foot in the last century. Although there are many projections regarding future sea level changes, the Corps' policy is one of concern rather than alarm. However, if the historic rate of rise were to continue, future flood levels would increase along with sea levels.

## **PROBLEM IDENTIFICATION**

### **EXPECTED FUTURE CONDITIONS**

Existing and future activities on the coastal floodplain in the study area is regulated and/or controlled by numerous laws, ordinances and policies. The National Flood Insurance Program, administered by FEMA is currently in force in Milford. Under this program flood insurance zones and base flood elevation lines are established for the city. Subsidized flood insurance is then made available based on the Flood Hazard Factors of areas subject to flooding. To be eligible for Federal flood insurance, Milford has adopted floodplain regulations to protect life and property from flooding, and control development in areas that are subject to flooding.

The State of Connecticut has also been very active in establishing regulations and programs to control development of floodplain lands. These Acts form the basis for the Connecticut Department of Environmental Protection policy on floodplain management. Floodplain management is presently being pursued in Connecticut under the following Acts:

- Stream Channel Encroachment Act
- The Inland Wetlands and Water Courses Act
- The Tidal Wetlands Act
- Flood Management for State Agencies Act
- Structures and Dredging Act
- The Diversion Act- Coastal Area Management Act



The affect of these programs, regulations and policies will be to limit and control future development of the floodplain, and to promote the wise use of the low-lying coastal environment. Even with these regulations, the pressure for coastal development in Milford has not subsided. The recent and on-going development and redevelopment of what is considered "prime" coastal areas is expected to continue. However, current FEMA regulations require new construction or major reconstruction must have the first floor elevated above the 100 year flood height. Future inundation damages are not expected to increase substantially due to new construction.

## **PLANNING OBJECTIVES**

Water resources planning undertaken by Federal agencies is directed by the Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. The Federal objective of such studies is to contribute to national economic development (NED), consistent with protecting the Nation's environment, pursuant to environmental statutes and applicable executive orders and Federal planning requirements. Plans will, therefore, be developed in the interest of achieving the general objectives of enhancing national economic development and protecting environmental quality. National economic development is enhanced by increasing the value of the output of goods and services, and by improving national economic efficiency.

Based on an assessment of the problems and needs of the study area, and the goals of the non-Federal sponsor, the study has concentrated on the following planning objectives:

- Reduce potential tidal flood damage in Milford.
- Preserve or enhance the environmental resources of coastal floodplain areas.

## **STUDY AND PLANNING CRITERIA**

Recommendations to proceed to the next study stage (feasibility phase) are guided by two general constraints:

- a) Information be sufficiently detailed to determine that at least one potential solution will likely have Federal interest and be in accord with current policies and budgetary priorities; and
- b) The potential solution be supported by the non-Federal (local) sponsor, and consistent with their policies and statutes on coastal zone management, flood plain management and flood control. Since this study focused on flood damage reduction, Federal interest was established if a potential solution was economically justified and the local sponsor demonstrated support for further study.

## PLAN FORMULATION

### FLOOD REDUCTION MEASURES

To prevent or reduce flooding and its associated damages, there are two basic types of protection available; structural and nonstructural. These measures differ in that structural measures affect the limits of the flood waters while nonstructural measures affect activities within the floodplain. Both types of flood control measures, or possible combinations, are evaluated to address the flood problem.

*Structural Measures* - Structural measures are characterized as those measures that prevent or reduce inundation of the floodplain. The following structural measures, either singularly or in combination with others, represent potential solutions to coastal flooding.

- Seawalls
- Dikes (to including the following)
  - (a) Dune restoration and beach nourishment
  - (b) Road raising
- Bulkheads
- Tide gates or navigation gates
- Pumping facilities (used in conjunction with walls or dikes)

*Nonstructural Measures* - Nonstructural flood control measures are those measures which prevent or mitigate losses experienced by existing flood prone properties and activities, while allowing temporary inundation of the floodplain. Applicable nonstructural measures are presented below:

*Floodproofing Techniques* - Floodproofing, by definition, is a body of techniques for preventing damages due to floods; requiring adjustments both to structures and to building contents. It involves keeping water out as well as reducing the effects of water entry. Such adjustments can be applied by an individual or as part of a collective action either when buildings are under construction or during remodeling or expansion of existing structures. They may be permanent or temporary.

Floodproofing, like other methods of preventing flood damages, has its limitations. It can generate a false sense of security and discourage the development of needed flood control and other actions. Indiscriminately used, it can tend to increase the uneconomical use of flood plains resulting from unregulated flood plain development. Although numerous measures exist, the following techniques apply to both study areas:

- Temporary or permanent closures for openings in existing structures
- Raising existing structures
- Rearranging or protecting damageable property within an existing structure
- Relocation of existing structures and/or contents from the flood prone areas



*Flood forecast, warning and evacuation* - This is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy includes:

- A system for early recognition and evaluation of potential floods.
- Procedures for issuance and dissemination of a flood warning.
- Arrangements for temporary evacuation of people and property.
- Provisions for installation of temporary protective measures.
- A means to maintain vital services.
- A plan for post flood reoccupation and economic recovery of the flooded area.

*Floodplain regulations* - Through proper land use regulation, floodplains can be managed to insure that their use is compatible with the severity of a flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building and housing codes. Their purpose is to reduce losses by controlling the future use and changing the existing use of floodplain lands.

Regulations covering the development of the flood plains are already in effect in the city of Milford. Regulations may be relatively prohibitive or may allow construction, provided the new structures are floodproofed and/or elevated above a designated flood elevation.

*Flood Insurance* - Flood insurance is not really a flood damage prevention measure as it doesn't reduce damages, rather it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, the annual flood losses and to make flood insurance protection available to property owners. Prior to this program, the response to flood disasters was limited to the building of flood control works and providing disaster relief to flood victims.

Utilization of nonstructural measures usually requires a combination of measures to adequately protect activities in a flood plain. For example, raising existing structures above projected flood heights would not completely solve the flood problem. Residents or other occupants must be warned of expected flooding so that the area can be evacuated. In addition, further development of the floodplain should be regulated to prevent future flood damages.

## **SCREENING OF MEASURES**

The preliminary screening of alternatives was accomplished in the West Central Connecticut Reconnaissance Study. During the course of the reconnaissance study, numerous meetings were held with State of Connecticut officials and representatives of Milford. The purpose of these meetings was to identify potentially high damage areas and possible alternative flood damage reduction measures. In conducting the initial evaluation of these sites, all practical methods of reducing or eliminating potential flood damage was given consideration.

To determine which sites and alternatives warranted further study, an initial screening process was conducted. Factors considered during this process included the potential for flood damage, the possible environmental and social impacts, engineering feasibility, and public acceptability of identified alternatives. This preliminary screening process, which considered the views and desires of local interests, was conducted in conjunction with the Connecticut Department of Environmental Protection, Coastal Area Management staff.

*Sites and Alternatives Studied:* Eight sites covering most of the coastline of Milford were originally reviewed by the West Central Connecticut Study. Two of these sites were: Cedar Beach and Fort Trumbell/Silver Beach. Alternatives considered for Cedar Beach included road raising, relocation and raising structures. Road raising was determined to have no significant impact on flood damage reduction, and relocation was considered impractical and too expensive, as well as politically unacceptable. Sand dune restoration and beach nourishment at Cedar Beach was not feasible because of their high cost, with respect to the raising structures alternative, and the potential adverse environmental impacts. Beach nourishment has the potential to impact shorebird species through the destruction of potential nesting habitat. The west end of Cedar Beach is a state owned wildlife sanctuary. The sanctuary is part of an 840-acre salt marsh near the mouth of the Housatonic River.

Alternatives originally considered for Silver Beach included dune restoration/beach nourishment and raising structures. Another marsh area extends shoreward of Silver Beach, along Great Creek. This marsh has under gone recent restoration with channelization of the creek, and installation of a flood control gate. Effects associated with dune and beach nourishment plan would include traffic and noise disturbance during transport and deposition of sand, as well as the potential destruction of shorebird nesting habitat. In view of the foregoing the only alternative that would be both publicly acceptable and have the least environmental impact to both areas would be the raising of individual structures.

Costs of raising structures at these two locations were evaluated further by estimating the average size of the first floor area for homes that are located within the 100-year flood plain. The average size of the first floors was developed based on contour mapping provided by the city of Milford. This area was multiplied by an estimated cost of \$28.00 per square foot, to raise a wood frame structure. The average first floor area of homes at these sites is about 1,050 square feet, resulting in an average raising cost of \$29,000. Based on these costs the following table presents the results of the West Central Connecticut Study:

**TABLE 1**  
**WEST CENTRAL CONNECTICUT STUDY RESULTS**

AREA	STRUCTURES	FIRST COST	ANNUAL COST	ANNUAL BENEFIT
Silver Beach/ Ft. Trumbell	401	\$11.2 million	\$984,000	\$455,600
Cedar Beach	115	\$3.2 million	\$282,000	\$185,700

As a result of the initial screening of available flood control alternatives accomplished by the West Central Connecticut Study, Silver and Cedar Beach areas were not recommended for further evaluation. Preliminary analysis indicated there was no economically justified plans to raise homes in the Silver and Cedar Beach areas. However because of the scope of the study, which included 8 communities and over 12,000 structures, many assumptions were made which may have affected the benefit analysis and project justification. Further analysis to confirm some of the more critical assumptions was required before a final decision could be made.

This second stage of screening was conducted under the Section 205 authority. At the request of the city the Fort Trumbell area was excluded and only the Silver Beach area was investigated. There are 190 houses in the 100 year flood plain at EL.10.4 ft. NGVD in the Silver Beach area. The Cedar Beach area, between Derby Avenue and Francis Street, has 52 structures in the 100-year flood plain. The ground elevation at each structure was estimated using a 1 inch equals 100 foot, 2 foot contour mapping provided by the city. The first floor elevations of the structures were determined by estimating the height of the first floor above the ground, for each structure, during a field visit. Table 2 summarizes the flood elevations, frequencies and the number of structures with first floors in each flood zone for the 50 and 100 year frequency flood events.

**TABLE 2  
STRUCTURES IN THE FLOOD PLAIN**

<b>1st Floor Elevation</b>	<b>Frequency</b>	<b>No. of Structures</b>	
		<b>Silver Beach</b>	<b>Cedar Beach</b>
Below 10.4 ft.	100 year	190	52
Below 9.7 ft.	50 year	171	40

Flood frequencies and elevations are provided in the Hydrologic Analysis Appendix on Plates 6 & 8. The flood stages presented on the plates represent Long Island Sound's stillwater elevations in the Milford area and reflect the current interior stage frequency relationships including the recent flood damage prevention measures.

The Structure Inventory for Damage Analysis (SID) computer program was used to calculate the total annual damages for each structure. The assessed value of the structure and it's first floor elevation were the major input parameters for this analysis. The total annual damages for all structures in each area were calculated using the recurring losses for each event as summarized in Table 3.

**TABLE 3  
RECURRING LOSSES BY EVENT**

<b>Location</b>	<b>50 Year Losses</b>	<b>100 Year Losses</b>
Silver Beach	\$1.88 million	\$5.70 million
Cedar Beach	\$700,000	\$1.95 million



The annual benefit for each structure was determined by raising the first floor to the 50 year and 100 year flood elevation and eliminating the damages below that point. The annual damages to each structure was recalculated and subtracted from the total annual damage to determine the annual benefit. Costs and benefits for these plans were developed based on providing protection from a 1 percent (100 year) annual chance flood event. Annual costs were developed using a project economic life of 50 years and the current interest rate of 8-3/4%. The benefits are summarized in Table 4.

**TABLE 4  
TOTAL ANNUAL BENEFIT**

<b>Frequency</b>	<b>First Floor Elevation Level of Protection</b>	<b>Silver Beach</b>	<b>Cedar Beach</b>
100 year	10.4 ft.	\$136,000	\$93,000
50 year	9.7 ft.	\$84,000	\$58,000

To determine if a project is economically justified and eligible for federal participation, the annual benefit of the project must exceed the annual cost. The costs estimated for the original study were based on curves developed by FEMA which are general in nature and adequate for use in a preliminary analysis. However, for this investigation it was necessary to update these costs. Raising homes in these areas would involve the following:

- Raising the structure;
- Replacing/rebuilding the foundation (piles or foundation walls would be used);
- Placing the structure on the elevated footing;
- Relocating/extending utilities;
- Extending assesses to structure;
- Temporary relocation of building occupants.

Costs were estimated for each of these actions based on other Corps of Engineers studies and adjusted for this specific area. The costs were based on the type of structure, the height it needed to be raised and whether or not it had a basement. The following table summarizes the results of the cost analysis for each area:

**TABLE 5  
TOTAL RAISING COSTS**

<b>First Floor Elevation</b>	<b>Silver Beach</b>	<b>Cedar Beach</b>
10.4 ft.	\$6.27 million	\$1.72 million
9.7 ft.	\$5.13 million	\$1.20 million

Benefit Cost Ratio's were calculated to determine if any of the areas have economically justified projects. For the 100 flood event Silver Beach has a 0.24 BCR and for Cedar Beach 0.60. For the 50 year flood event the BCR's was 0.18 and 0.54 respectively for each area. Table 6 summarizes these results.

**TABLE 6**  
**PROJECT JUSTIFICATION**

	100 YEAR RAISING PLAN	
	Silver Beach	Cedar Beach
Annual Benefits	\$136,000	\$93,000
Annual Costs	\$557,000	\$153,000
BCR	0.24	0.60
	50 YEAR RAISING PLAN	
	Silver Beach	Cedar Beach
Annual Benefits	\$84,000	\$58,000
Annual Costs	\$456,000	\$107,000
BCR	0.18	0.54

By comparing the annualized cost and benefits with the flood protection plans, it is shown that costs exceed the benefits.

## **SUMMARY OF PUBLIC COORDINATION**

Coordination with the city of Milford, State of Connecticut Department of Environmental Protection and property owners of the Silver Beach and Cedar Beach areas was initiated and maintained during the reconnaissance study. All concerned parties have been kept informed of the project status during the study phase by individual contact during topographic and flood damage surveys.

## **CONCLUSIONS**

The Silver Beach area of Milford has changed considerably over the past 5 years, and subsequent flood damage studies have revealed considerably less flood damages during the more frequent flood events. The primary reason for this reduction has been the completion of the Great Creek Tidal Gate Flood Control Project at Silver Beach. At the Cedar Beach area the majority of the residential structures, first floor elevations, have been constructed above the 100 year flood event. The overall affect of homeowners raising their first floors elevations, has been that the risk and severity of flood damages has been significantly reduced.

## **RECOMMENDATIONS**

Property owners are encouraged to continue to purchase Federally subsidized flood insurance. Further, the city of Milford is urged to continue to assure that all new construction follow the Federal Flood Insurance Guidelines. It is also recommended that early warning and evacuation of residents be given serious consideration by non-Federal interests for all flood prone areas along Milford's coast.

## **APPENDIX**

### **HYDROLOGIC REVIEW & ANALYSIS**



HYDROLOGIC ANALYSIS  
FOR  
FLOOD CONTROL  
MILFORD, CONNECTICUT

BY

HYDROLOGIC ENGINEERING BRANCH  
WATER CONTROL DIVISION  
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SILVER BEACH AND CEDAR BEACH  
MILFORD, CONNECTICUT

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SILVER AND CEDAR BEACH  
MILFORD, CONNECTICUT

1. PURPOSE AND SCOPE

The purpose of this report is to present hydrologic analysis and information pertinent to reconnaissance planning studies for flood control improvements in Milford, Connecticut. Flooding has been identified as a problem in the areas of Silver and Cedar Beaches. This investigation is conducted under Section 205 Authority.

2. AREA DESCRIPTION

Silver Beach, a residential community comprised of year-round and summer homes, is situated in the south-central portion of Milford. Great Creek, a small water course comprising of East and West Branches, drains into a tidal estuary within the limits of the Silver Sands State Park located to the west of Silver Beach (see plate 1). Cedar Beach is principally a summer home community in the southern portion of the Milford, and is located at the confluence of the Housatonic River and Long Island Sound (see plate 1).

3. CLIMATOLOGY

a. General. The southern coastal area of New England has a temperate and changeable climate marked by four distinct seasons. Owing to the moderate influence of Long Island Sound and the Atlantic Ocean, and particularly the variable movement of high and low pressure systems approaching from the west and southwest, extremes of either hot or cold weather are rarely of long duration. In the winter, coastal storms frequently bring rainfall to the shore areas and snow to the inland more northerly regions of Connecticut. The prevailing winds are northerly in the fall and winter, northwesterly in the spring, and southerly in the summer. High winds, heavy rainfall and abnormal high tides occur with unpredictable frequency. Hurricanes occur most frequently during August, September, and October.

b. Temperature. The mean annual temperature in Milford is approximately 51 degrees Fahrenheit, with January and February the coldest months averaging 30 degrees Fahrenheit and July the warmest, 73 degrees Fahrenheit. Freezing temperatures are common from late November through March. Table 1 summarizes the monthly and annual mean, maximum and minimum temperatures recorded at the Bridgeport National



Weather Service station. Temperatures are based on the 80-year period of record from 1896 through 1975.

c. Precipitation. The average annual precipitation over the Milford area is about 41 inches and evenly distributed throughout the year. Table 2 contains a summary of monthly and annual average precipitation amounts at the Bridgeport station for the 42-year period of record, 1948 through 1989, inclusive.

d. Snowfall. Snowfall in the Milford area averages about 25 inches. Average monthly and annual snowfall for the Bridgeport station, based on the 42-year period from 1948 through 1989, is shown in table 3.

TABLE 1

MONTHLY TEMPERATURES  
BRIDGEPORT, CONNECTICUT  
(Degrees Fahrenheit)

<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	30.1	68	-14
February	30.4	70	-20
March	38.4	85	1
April	48.7	97	9
May	57.7	95	26
June	68.1	99	34
July	73.8	103	44
August	72.2	101	38
September	65.9	98	32
October	55.4	90	20
November	44.4	80	8
December	33.1	67	-12
Annual	51.5	103	-20

TABLE 2

MONTHLY PRECIPITATION RECORDS  
BRIDGEPORT, CONNECTICUT  
(Inches)

<u>Month</u>	<u>Mean</u>
January	3.17
February	2.98
March	3.76
April	3.70
May	3.66
June	3.10
July	3.75
August	3.57
September	3.00
October	3.20
November	3.86
December	<u>3.49</u>
Annual	<b>41.32</b>

TABLE 3

AVERAGE MONTHLY SNOWFALL  
BRIDGEPORT, CONNECTICUT  
(Inches)

<u>Month</u>	<u>Mean</u>
January	7.61
February	7.31
March	4.51
April	0.45
May	0.00
June	0.00
July	0.00
August	0.00
September	0.00
October	0.01
November	0.64
December	<u>5.01</u>
Annual	<b>25.42</b>

#### 4. TIDAL FLOOD PROBLEMS

a. General. Tidal flooding within the study area is caused primarily by hurricanes or extratropical storms. Hurricanes have been the most damaging, because their intensity has a greater effect on tide levels and wave heights. Hurricanes can be defined as tropical cyclones with a central barometric pressure of 29.0 inches or less and a maximum windspeed in excess of 75 miles per hour. In the northern hemisphere they consist of winds revolving in a counterclockwise direction around a calm center or "eye". The diameter can vary considerably, from as small as 50 to 75 miles across to over 500 miles. Winds at the outer edge are usually light and increase in intensity as they approach the center. Hurricanes that have had the most severe effect on the study area usually approach from the south after curving east of Florida and skirting the Middle Atlantic States. Following are descriptions of the more damaging historic hurricanes.

b. September 1938. Damage caused by tidal flooding from this hurricane was the greatest ever experienced in Long Island Sound. The center of the hurricane entered Connecticut perpendicular to the coast about 15 miles east of New Haven on 21 September and then proceeded northwesterly at a forward speed of 50 to 60 mph. The peak of the hurricane tide arrived about 1 to 2 hours before the predicted normal high tide throughout most of the Sound, causing extreme tide levels. The tidal surge at Bridgeport was about 7 feet higher than the predicted tide. Tidal surge reached its crest at 7:30 p.m. on the 21st. Total precipitation amounts recorded at Bridgeport from 13 to 21 September were 14.15 inches.

c. September 1944. The eye of this storm passed inland just west of Point Judith, Rhode Island, and continued in a northeasterly direction. The hurricane tide arrived in the Sound about mean tide at the eastern end, and about two hours after predicted high tide at the western end resulting in moderately high ocean levels. Precipitation during this hurricane was on top of the high antecedent condition and totalled 5 inches.

d. August 1954. The second most severe hurricane to strike southern New England in over 300 years occurred 16 years after the record 1938 event. The center of this storm crossed the shoreline of Connecticut near New London with a forward speed of about 45 mph and then followed a general northerly path across New England. As the hurricane surge occurred at or near predicted normal high tide within the Sound, tide levels rose to near record heights. Tidal

surges ranged from 5 to 8 feet higher than predicted tides. The total 2-day rainfall during hurricane "Carol" (31 August 1954) in the Bridgeport-Stratford area was only 1.72 inches.

e. September 1985 (Gloria). Hurricane "Gloria" made landfall in Westport, Connecticut after crossing Long Island Sound, at 12:15 p.m. The eye of the hurricane, then continued on its north-northeastward track, passing near Hartford before exiting the State at Suffield about 1:13 p.m. Wind gusts of hurricane force ripped through the southern and central, as well as the eastern portion of Connecticut, with the peak gust for the entire State recorded to 92 mph at Bridgeport. The lowest sea level pressure was 28.5 inches at Bridgeport. Other peak wind gusts included 82 mph at Hartford, 75 at New Haven, and 66 at Windsor Locks. Along the coast, up to 20,000 people were evacuated from their homes from Greenwich to Stonington, and hundreds of small craft were torn from their moorings and damaged or destroyed. Five docks were ripped up in Milford Harbor and about 100 pleasure craft were torn from their moorings. However, coastal flooding was at a minimum despite tides 2 to 4 feet above normal, since "Gloria" reached the coast near low tide.

## 5. TIDAL HYDROLOGY

a. Astronomical Tides. At Milford, tides are semidiurnal with two high and two low waters occurring during each lunar day. The resulting tide range is constantly varying in response to relative positions of the earth, moon, and sun; the moon having the primary tide producing effect. Maximum tide ranges occur when orbital cycles of these bodies are in phase. A complete sequence of tide range is approximately repeated over an interval of 19 years, known as a tidal epoch. At the National Ocean Survey (NOS) tide gage in Milford Harbor, the mean tide range and the mean spring flood range are 6.6 and 7.6 feet, respectively (see table 4 and plates 2 and 3). However, the maximum and minimum probable astronomic tide ranges at Milford have been estimated about 10.4 and 2.7 feet.

b. Storm Types. Two distinct types of storms, distinguished primarily by their place of origin as being extratropical and tropical cyclones, influence coastal processes in New England. These storms can produce above normal water levels and must be recognized in studying New England coastal problems.

(1) Extratropical Cyclones. These are the most frequently occurring variety of cyclones in New England. Low pressure centers frequently form or intensify along the boundary between a cold dry continental air mass and a warm



moist marine air mass just off the coast of Georgia or the Carolinas and move northeastward more or less parallel to the coast. These storms derive their energy from the temperature contrast between cold and warm air masses. The organized circulation pattern associated with this type of storm may extend for 1,000 to 1,500 miles from the storm center. The wind field in an extratropical cyclone is generally asymmetric with the highest winds in the northeastern quadrant. Since the storms center generally passes parallel and southeast of the New England coastline, highest onshore windspeeds are generally from the northeast. For this reason these storms are called "northeasters" by New Englanders.

TABLE 4

MILFORD HARBOR  
TIDAL DATUM PLANES

	<u>Tide Level</u> (ft. NGVD)
Maximum Astronomical High Water	6.4
Mean Spring High Water (mhws)	4.5
Mean High Water (mhw)	4.0
Minimum Astronomic High Water	1.9
Mean Tide Level (mtl)	0.7
National Geodetic Vertical Datum (NGVD)	0.0
Maximum Astronomic Low Water	-0.8
Mean Low Water (mlw)	-2.6
Mean Spring Low Water (mlws)	-3.1
Minimum Astronomical Low Water	-4.8

(2) Tropical Cyclones. These storms form in a warm moist air mass over the Caribbean and waters adjacent to the West Coast of Africa. The air mass is nearly uniform in all directions from the storm center. The energy for the storm is provided by the latent heat of condensation. When the maximum windspeed in a tropical cyclone reaches 75 mph, it is labeled a hurricane. Wind velocity at any position can be estimated based upon the distance from the storm center and forward speed of the storm. The organized wind field may not extend more than 300 to 500 miles from the storm center. Recent hurricanes affecting New England generally crossed Long Island Sound and proceeded landward in a northerly direction. Some of the more damaging hurricanes were described in the previous section.

c. Winds. When a steady wind starts to blow over a calm body of water, waves develop. The wave height and period increase with windspeed, the duration of wind and the distance (fetch) over which the wind blows. Exact details of the process are not yet fully identified, but the foregoing statements are universally accepted. The wave height and period may ultimately reach a maximum with duration or fetch of the wind. Hurricane winds generate gigantic waves, and their ultimate size depends upon force and duration of the wind and distance the wave travels. Driven by hurricane winds, the breaking waves will run up on shelving beach or overtop vertical structures well above the actual stillwater height, so reports of wave and flood damage from 5 to 25 feet above stillwater level are not uncommon. Rise of the tide due to the storm amounts to only 1 or 2 feet in the open ocean while its magnitude can reach 6 to 10 feet or more at coastal points.

d. Storm Tides. The total effect of astronomical tide combined with storm surge produced by wind, wave, and atmospheric pressure contributions is reflected in actual tide gage measurements. Since the astronomical tide is so variable at the study area, the occurrence time of the storm surge greatly affects the magnitude of the resulting tidal flood level. A sample of predicted and recorded tidal flood levels at Stratford, CT (near Silver and Cedar Beaches), showing the combined effects of astronomical tides and storm surge is shown on plate 4. Also shown is the predicted astronomical tide. The storm surge, defined as the difference between observed and astronomical tides can be determined from this plate.

e. Tidal Stage Frequency. An ocean tide frequency relationship for Bridgeport was previously developed utilizing a composite of (1) a Pearson type III distribution function, with expected probability adjustment, from analysis of historic and systematic observed annual maximum stillwater tide levels, and (2) a graphical solution by using Weibull plot positions based on the 48-year period of record from 1938 to 1986 including the partial duration series data. The resulting tide frequency curve adjusted for the sea level rise (0.1 foot per decade) is shown on plate 6. Because Cedar Beach is located along the open coast with no protective measure, this curve is considered applicable for Cedar Beach. The location of Bridgeport (where tidal stage frequencies were developed) relative to Milford can be seen on plate 5.

## 6. INTERIOR HYDROLOGY

a. Silver Beach. The Silver Beach area is situated in the south-central portion of Milford and extends about 4,500 feet along East Broadway (see plate 1). The highway and beach fronting Long Island Sound are generally about elevation 8 feet NGVD. West of East Broadway the area slopes down with residential development at elevations ranging from 4 to 6 feet NGVD. The watershed varies in elevation from sea level to 50 feet NGVD at its northernmost point near Town Street. Great Creek, draining into a tidal estuary, has a total drainage area of 620 acres and a single outlet to Long Island Sound at the southern end of Silver Beach and is equipped with a self-regulating tide gate. The gate consists of two 39 by 39-inch cast iron flap gates controlled by four large floats and two 54 by 81-inch cast iron sluice gates. The flap gates are designed to close when sea level rises to elevation 3.25 feet NGVD.

b. Runoff. Prior to construction of the new outlet structure and self-regulating tide gate, the interior area was exposed to high tides along with increased stages caused by rainfall runoff aggravated by poor drainage facilities. Interior runoff and resulting ponding levels at Silver Beach, at times of high tide, are more a function of rainfall volume than peak rate of runoff. Minimum elevations in the marsh area are about 2.5 feet NGVD. Since installation of the tide gate which is designed to close during high tides and open during ebb tides, the interior area is protected from tidal inflow for tidal flood events up to the point where tide waters would overtop East Broadway Street, about elevation 8 feet NGVD. When developing coincident interior runoff values, several steps were taken. First, peak discharge frequency curves were developed from gaged records on the Yantic River at Yantic and Sasco Brook near Southport. These curves were then transferred to Great Creek by respective drainage area ratio to the 0.7 power. Since the tide gate is designed to close at elevation 3.25 feet NGVD, rainfall runoff at high tide must be temporarily stored in the estuary. Analysis of predicted high tide stage hydrographs shows that interior runoff must be stored for 3 to 4 hours during every high tide cycle. Runoff volumes were determined by use of the developed peak discharge frequencies from analysis of Sasco Brook for the 2, 5, and 10-year frequencies assuming a 3-hour period of tide gate closure. A 10-year tidal event (elevation 8.5 feet NGVD) is the point where significant tidal overtopping of East Broadway Street will begin. A second approach was taken that involved the use of rainfall runoff. Comparative rainfall frequency duration data, as reported in U.S. Weather Bureau TP40, is listed in table 5.

TABLE 5

RAINFALL FREQUENCY DURATION  
USWB TECHNICAL PAPER 40  
MILFORD, CONNECTICUT  
(Inches)

<u>Annual Frequency</u>	<u>Duration in Hours</u>					
	<u>1</u>	<u>2</u>	<u>3</u>	<u>6</u>	<u>12</u>	<u>24</u>
50% (2 year)	1.3	1.7	1.9	2.4	2.7	3.4
20%	1.8	2.2	2.5	3.1	3.5	4.3
10%	2.1	2.6	2.8	3.5	4.1	5.0
2%	2.6	3.4	3.7	4.5	5.5	6.2
1% (100 year )	3.0	3.7	4.2	5.1	6.1	7.1

Loss rates of 0.1 inch per hour were assumed and 3-hour runoff volumes were computed for the 2, 5 and 10-year rainfall events. The computed volumes were somewhat higher than those developed by use of peak discharge frequencies.

c. Ocean Overtopping. As stated previously, East Broadway Street and the fronting Silver Beach have an average elevation of about 8 feet NGVD. Therefore, stillwater tide levels exceeding 8 feet will begin to overtop the street and flow into the Great Creek tidal estuary. To determine the volume of tidal overtopping, hydrographs for the 1938 and 1944 hurricanes (shown on plate 4) were analyzed. Also, 2-foot contour maps of the city of Milford show East Broadway Street at elevation 8 feet NGVD for a total length of about 2,400 feet. Therefore, we assume the roadway would act as a weir during events such as the 1938 and 1944 hurricanes and overtopping volumes were computed (above elevation 8). Stage hydrographs shown on plate 4 and the conventional weir formula with a length of 2,400 feet and an assumed "C" coefficient of 2.8 were used. In addition, since the 1938 and 1944 events had associated rainfall, runoff volumes were computed by analyzing the Yantic River flow data during the hurricane. The results of this analysis are shown in table 6.

TABLE 6

COMPARATIVE HYDROLOGIC DATA FOR  
HISTORIC FLOODS

<u>Flood Event</u>	<u>September 1938</u>	<u>September 1944</u>
Approximate Interior Level (ft)	8.2	7.7
Annual Frequency Estimate (%)	4	6
Approximate Overtopping and Rainfall Volume (ac-ft)	590	410
Ocean Stillwater Tide Level (ft, NGVD)	9.2	8.8
Maximum 1 hr Rainfall (inch)	N/A	1.5
Storm-Rainfall (inch/hr)	5.08/24hrs	3.52/24 hrs

d. Interior Storage Capacity. Ponding elevation-capacity relations for the Great Creek interior area were developed by planimetering available 2-foot contour maps of the area. The developed storage-capacity curve within the watershed is shown on plate 7. The ponding volume is approximately 35 acre feet at elevation 3.25 feet NGVD.

e. Interior Flood Stage-Frequency. An existing condition interior flood stage-frequency curve, the basic curve for determining flood damage frequencies at Silver Beach, is shown on plate 8. This curve was developed using interior runoff volumes determined from discharge frequency curves for the 2 to 10-year runoff events and adding these volumes to an assumed initial estuary level of 3.25 feet NGVD. Results of the analysis of the 1938 and 1944 hurricanes were used to determine elevations for events exceeding the 10-year frequency as shown in table 6. We then assumed that the curve would approach the ocean stillwater tide frequency curve at approximately a 2 percent chance of occurrence (50 year) when the road would be overtopped by approximately 2 feet.



## 7. WAVES

a. General. The intent of studies undertaken is to determine stage frequencies for damage and economic assessment. One possible solution would involve raising structures to prevent flood damage. Federal Emergency Management Agency (FEMA) guidelines are to raise structures above the 100-year stillwater plus the elevation associated with computed wave heights for a 100-year event.

b. Cedar Beach. For the open coast such as Cedar Beach, the FEMA published wave crest is at elevation 16 feet NGVD. Therefore, structures raised in this area should have first floor elevations above 16 feet NGVD.

c. Silver Beach. The interior area of Silver Beach has a one percent stillwater tide level of 10.4 feet NGVD. Although this level is the same as the open coast, wave heights should be somewhat reduced due to protection provided by East Broadway and Ocean Side Beach. Suggested elevations for first floor levels in this area are 14 feet NGVD. If economic studies indicate raising structures to be cost effective more detailed overtopping and wave analysis will be undertaken during feasibility studies to better define wave conditions and first floor levels of these structures.

## 8. REFERENCES

a. U.S. Army Corps of Engineers, Tidal-Flood Management, West Central Connecticut, June 1988.

b. Federal Emergency Management Agency (FEMA), Flood Insurance Study, City of Milford, Connecticut, July 2, 1987.

c. Bureau of Public Works, State of Connecticut, Flood Control-Great Creek, Silver Sand, Milford, Connecticut.

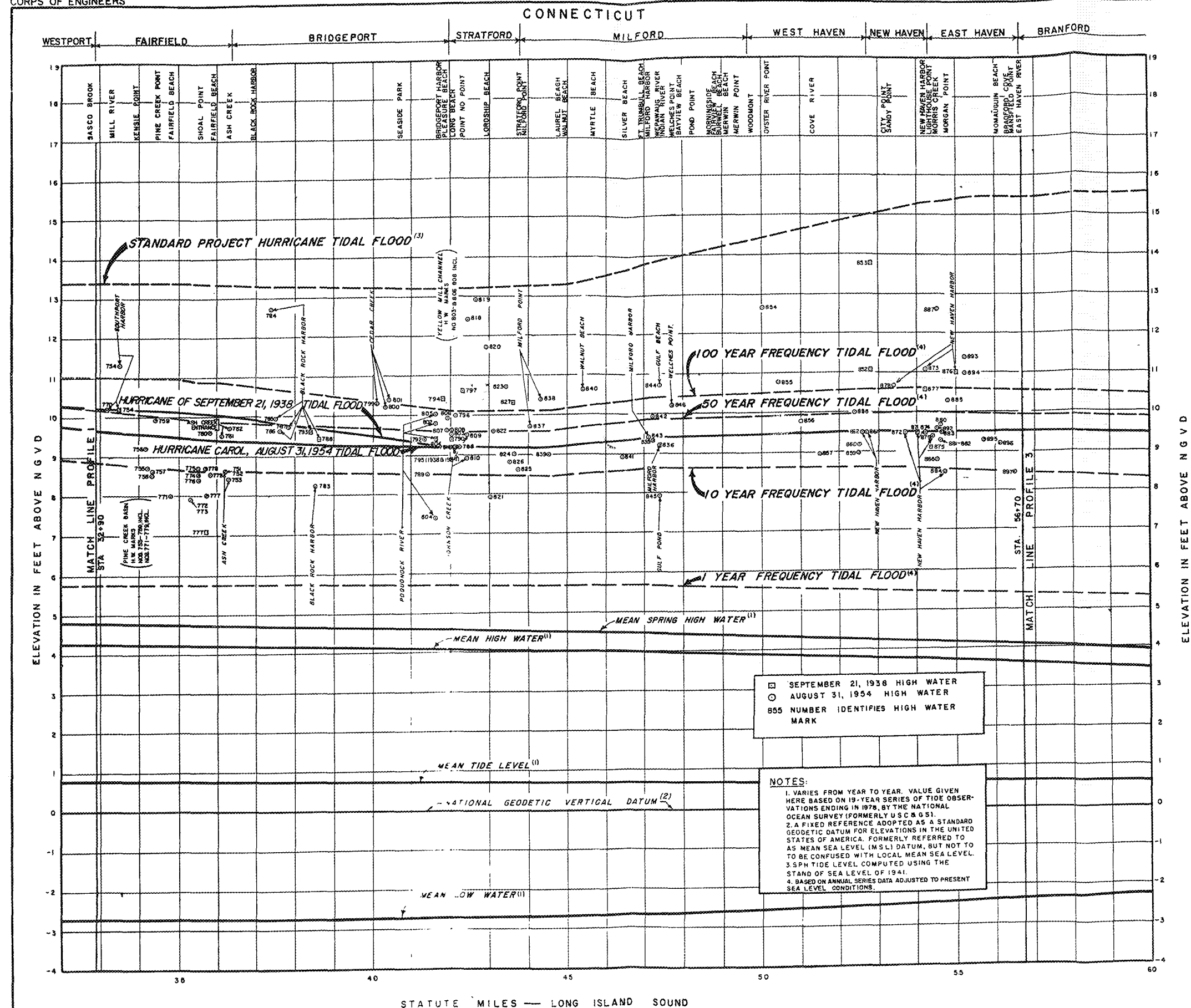
d. U.S. Department of Commerce, Technical Paper No.40, Rainfall Frequency of the United States, May 1961.

e. U.S. Army Corps of Engineers, Engineer Manual 1110-2-1412, Storm Surge Analysis, 1986.



SILVER BEACH AND  
CEDAR BEACH  
GENERAL LOCATION  
MAP

HEB 19

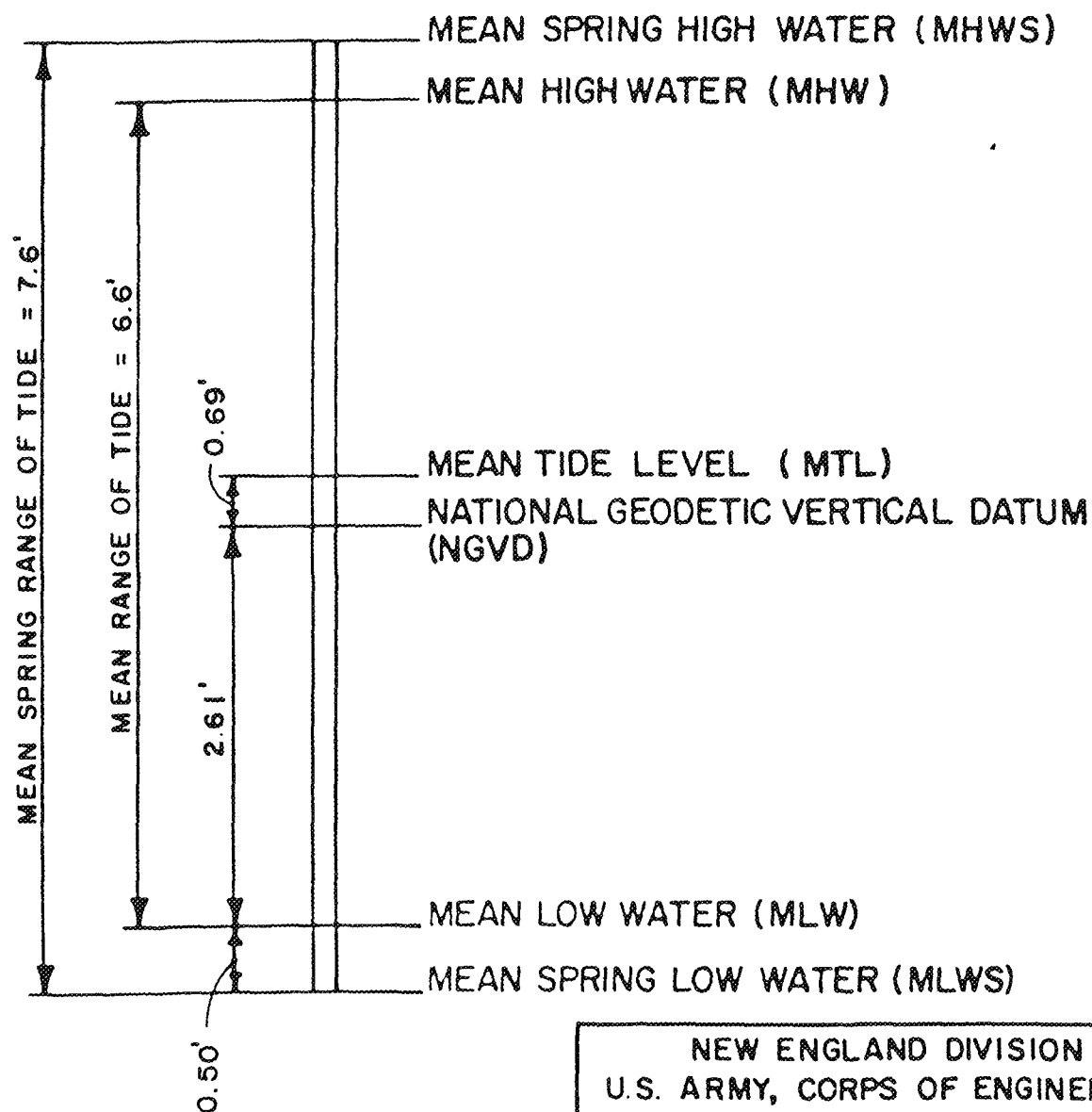


NEW ENGLAND COASTLINE  
TIDAL FLOOD SURVEY  
**TIDAL FLOOD PROFILE NO. 2**  
FAIRFIELD, CONN., TO  
EAST HAVEN, CONN.

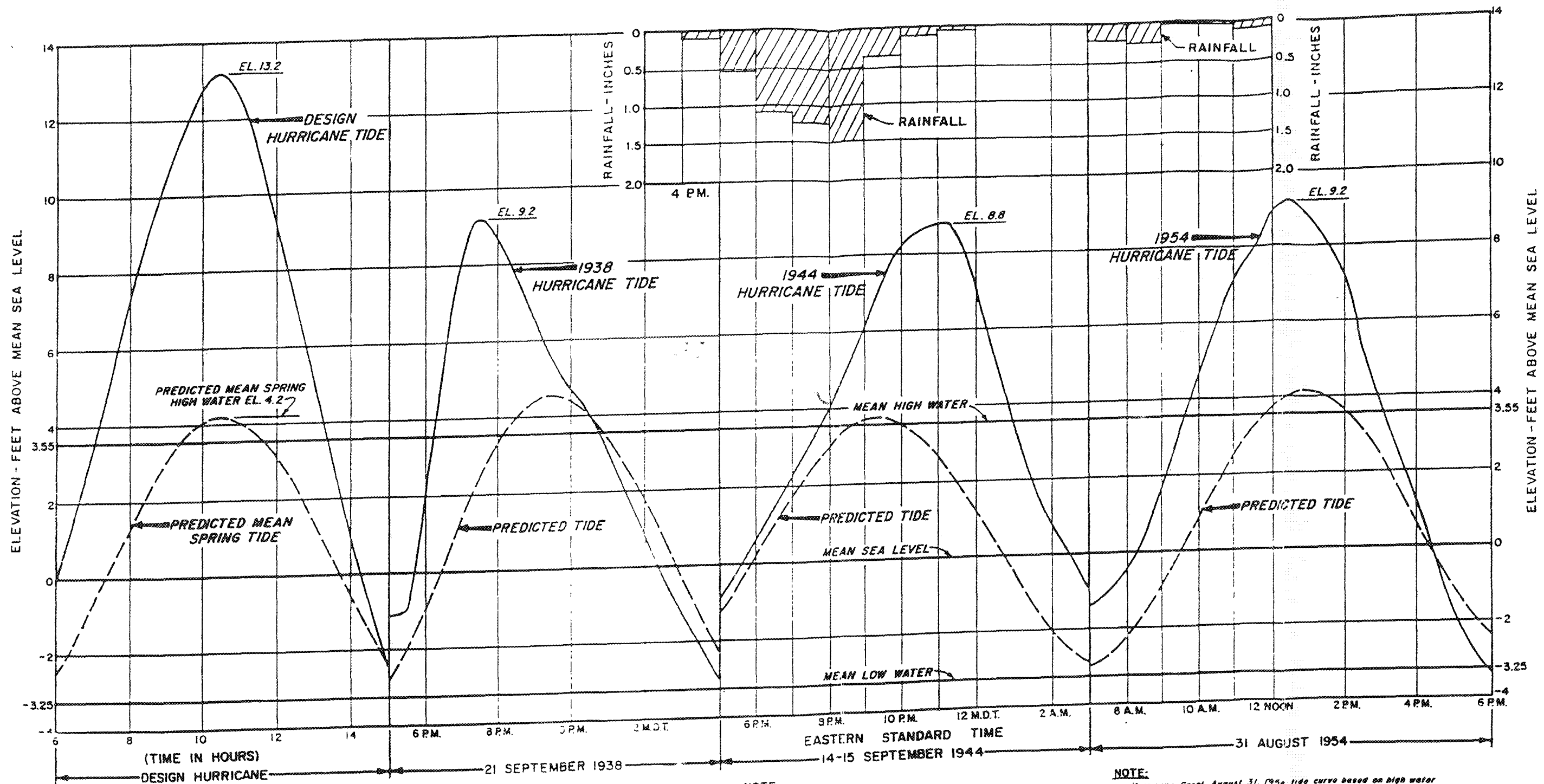
DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.  
SEPTEMBER 1988

# TIDAL DATUM PLANES

## MILFORD HARBOR, CONNECTICUT



NEW ENGLAND DIVISION  
U.S. ARMY, CORPS OF ENGINEERS  
WALTHAM, MASS. 1991



**NOTE:**  
Design hurricane tide curve based on Texas A. & M. surge calculations for a design storm with a track most critical to Long Island Sound and with the peak of the surge coincident with the peak of a predicted mean spring tide.

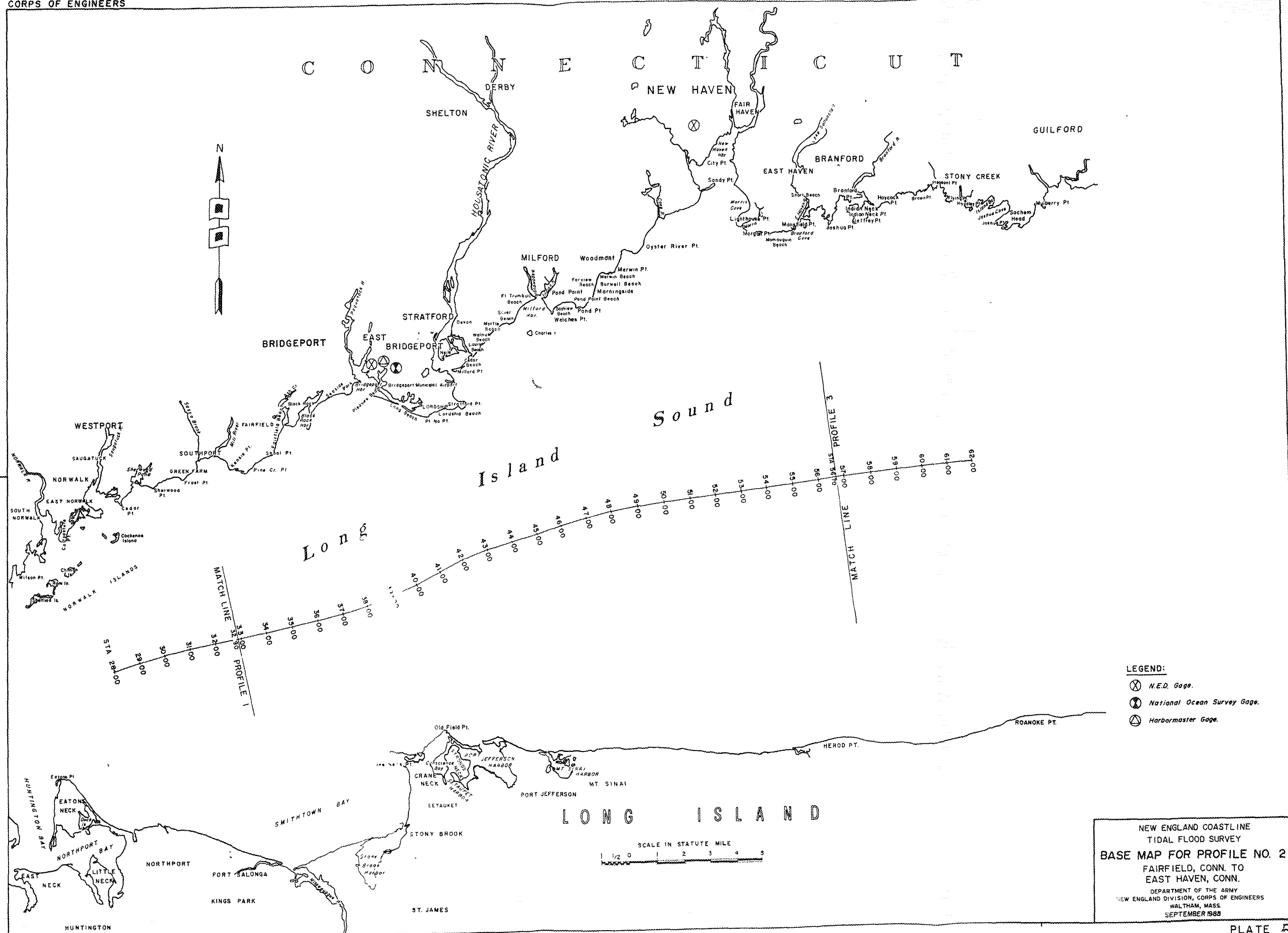
**NOTE:**  
Hurricane of September 21, 1938 tide curve based on high water marks in the vicinity of Stratford and hurricane tide at Willets Point, N.Y. stage related to Stratford.

**NOTE:**  
Hurricane of September 14-15, 1944 tide curve based on high water marks in the vicinity of Stratford and hurricane tide at New London, Conn. stage related to Stratford.

**NOTE:**  
Hurricane Carol, August 31, 1954 tide curve based on high water marks in the vicinity of Stratford and hurricane tide at Bridgeport, Conn. stage related to Stratford.

STRATFORD CONNECTICUT  
TIDE CURVES  
DESIGN, 1938, 1944 & 1954 HURRICANES  
DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS





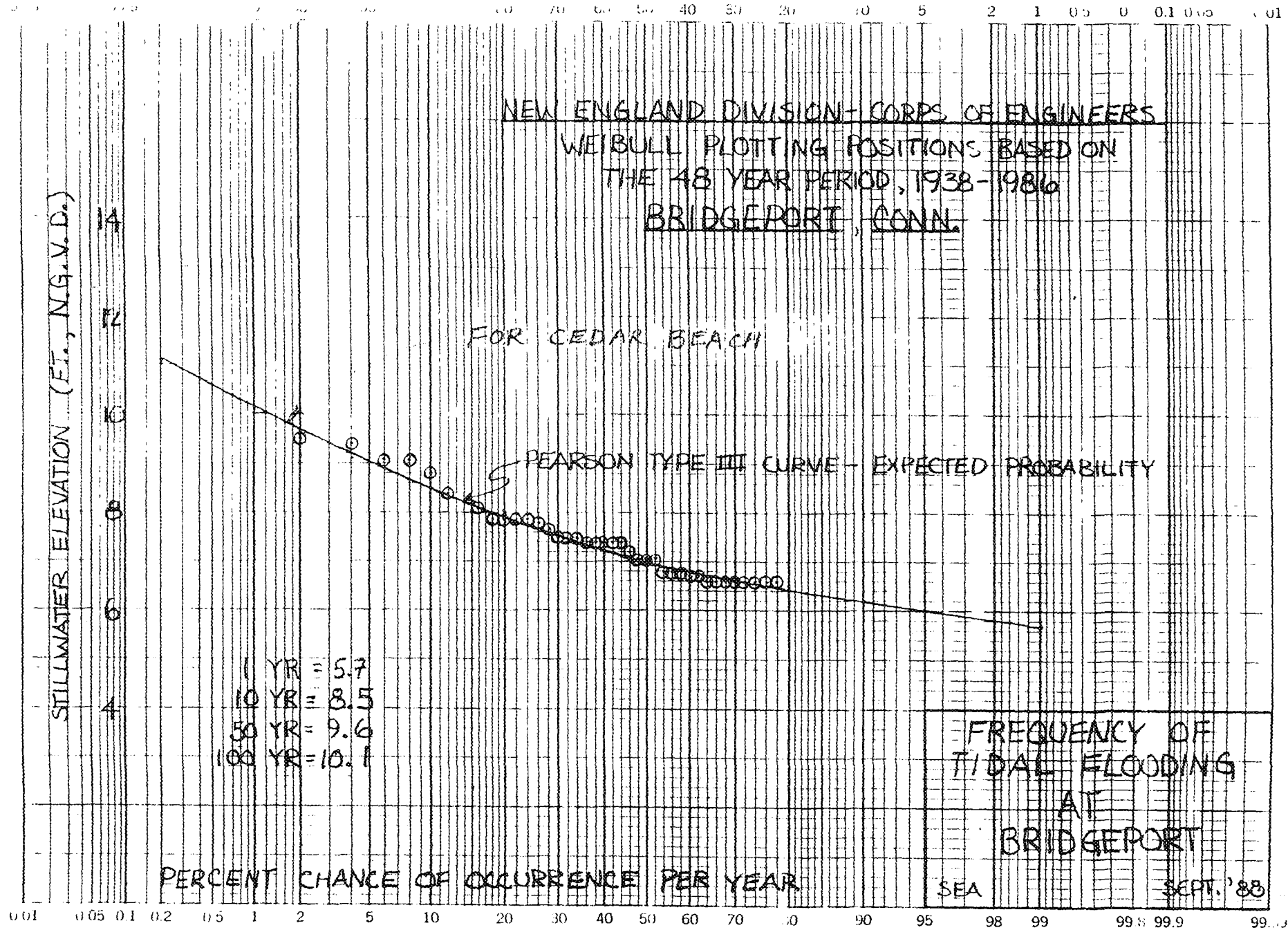
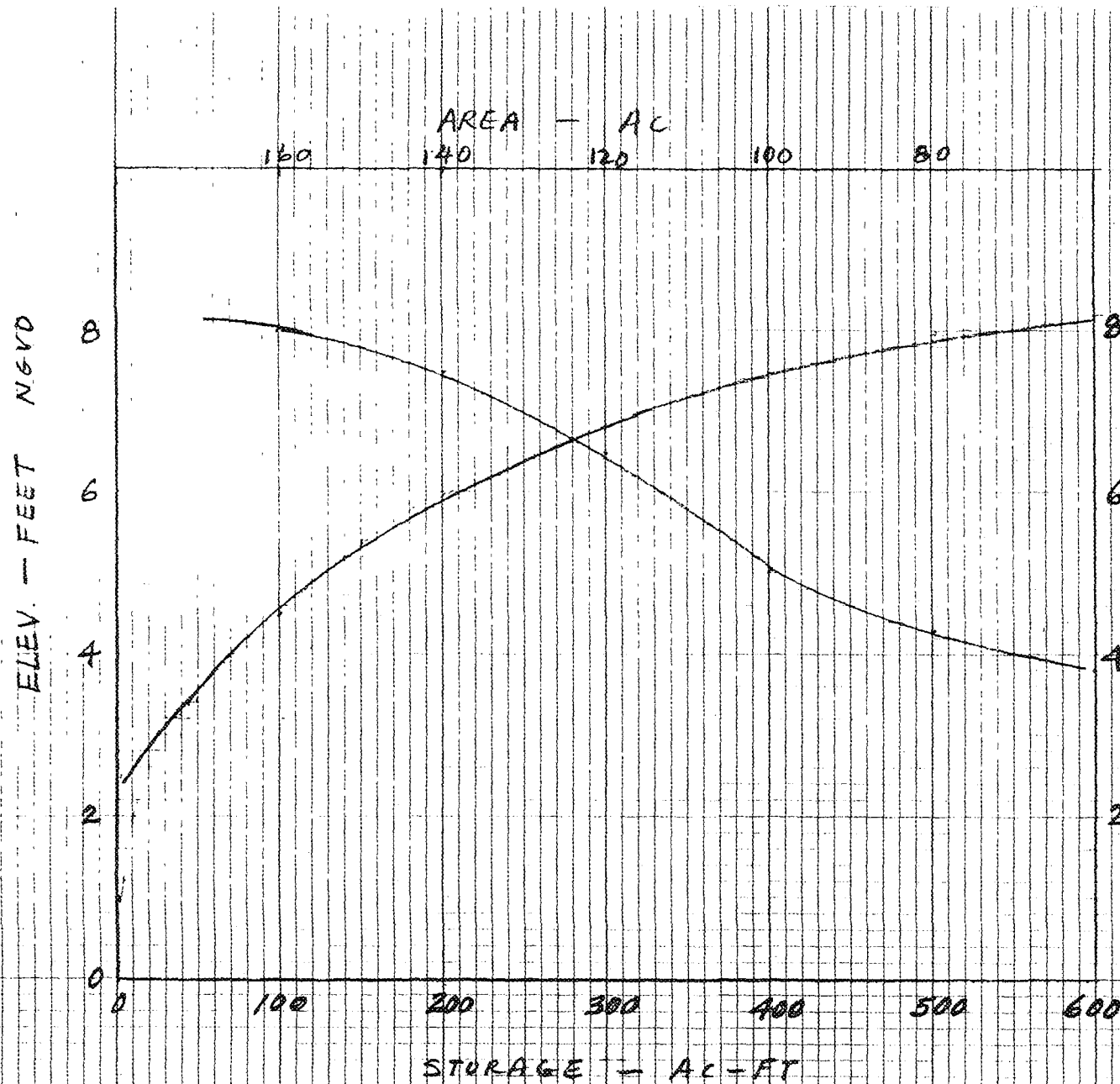


Plate 6



Great Creek Watershed  
Milford, Ct.

STORAGE - AREA  
CAPACITY CURVES

HEB

1991

PLATE 8

ELEVATION - FEET (NGVD)

